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THE DISPERSAL OF PSEUDOCOCCIDAE (HEMIPTERA-HOMOPTERA) BY AIR CURRENTS IN THE GOLD COAST.

By A. H. STRICKLAND

(Entomologist, Division of Plant Pathology, West African Cacao Research Institute, Tafo, Gold Coast).

INVESTIGATIONS into the biology and bionomics of the species of mealybugs of the genus *Pseudococcus* and related genera now known to be vectors of cacao virus diseases on the Gold Coast indicated that the young nymphal stages of these insects were almost certainly dispersed to an unknown extent by air currents. Since the "crawler" stages were known to be the most efficient vectors (Posnette and Strickland, 1948) it was of some importance to determine the extent of this form of dispersal.

A number of types of trap have been evolved for the purpose of collecting insects moving through the air (Williams and Milne, 1935; Davies, 1935; Dominick, 1940; Broadbent, 1946, etc.). In view of the small size of the insects it was desired to catch (0.4 mm. in length), it was decided that a series of stove-pipe traps of the type used by Broadbent (*loc. cit.*) should be used for the present investigation. Details of the traps, the locations at which they were set up and the results obtained are discussed below.

METHODS.

The traps used were made of old stove piping, of external diameter 6 inches, and cut into lengths of 24 inches. The basal 4 inches of each cylinder was made to fit into a cup consisting of a strip of galvanized iron fitted to a circular wooden ring $6\frac{1}{2}$ inches in diameter. The cup and base of the cylinder were bored to take two $7\frac{1}{2}$ -inch bolts, and the cup was screwed to the top of a wooden pole sunk firmly into the ground. It was thus possible easily to remove a trap cylinder by unscrewing the fixing bolts and withdrawing them, and a clean trap could immediately be replaced on the pole, ensuring continuity of catch whilst the removed cylinder was being examined. Each trap was given two coats of white enamel paint at the start of the experimental period, and in spite of exposure in the field in all weathers in the humid forest zone of the Gold Coast, no trouble was experienced of cylinders or cups corroding.

Five traps were put up. Each station was chosen carefully so that there were no trees directly overhanging the site, and it was thus not possible for insects simply to drop on to a trap from an overhanging branch. It is assumed, therefore, that all insects caught on the traps were genuinely either flying in the air, or, if apterous, being carried in air currents. The traps were covered evenly with a layer of gammexane "Ostico," approximately a quarter of a pint of the "Ostico" being used per trap. The "Ostico" was specially made up to a tropical formulation by Messrs. Plant Protection Ltd., and stood up well to the torrential rains of the wet season, and the desiccation of the

Harmattan in the dry season. The traps were changed at fortnightly intervals for a period of one year. When a trap cylinder had been in the field for two weeks it was removed, replaced by a clean cylinder, and brought to the laboratory for examination. All insects caught in the "Ostico" were removed with the help of a lens and a needle, counted, and all coccids, or suspected coccids, subsequently washed in a mixture of ethyl acetate and acetic acid, cleared in 10 per cent. potassium hydroxide and stained and mounted for determination. The trap was then cleaned of "Ostico" by washing in kerosene, and a fresh coating of the grease put on before being returned to the field. To prevent migration of insects from the ground up the poles and on to the traps, the poles were thickly smeared with "Ostico" over a length of 2 feet.

SITUATION OF THE FIVE TRAPS.

Two traps were put up at Tafo (750 feet above sea level), one on a pole such that the base of the trap was 10 feet above ground level (at about the same height as the lower branches of the canopy of a mature cacao tree), the other on a pole 2 feet high. The poles were 8 feet apart, and are referred to below as "Tafo A" (2-foot pole) and "Tafo B" (10-foot pole).

A third trap was put up on a 10-foot pole at the Department of Agriculture Cacao Station at Oyoko, 13 miles due south of Tafo (700 feet above sea level). Three traps were thus standing in clearings in typical cacao farms, and were separated from the nearest cacao trees by distances of 20 to 30 feet.

The fourth trap was put up, on an 8-foot pole, in the Botanical Gardens at Aburi, at the south end of the Akwapim Ridge, 23 miles north of Accra (1400 feet above sea level). This trap was situated on the brow of a hill, with a clear unobstructed view to the south-west, and was 100 yards from the nearest cacao. The cacao was, however, bordered by a 30-foot tall wind-break hedge, and since the prevailing wind came from the south-west, it is not likely that many coccids caught on the Aburi trap came from the adjacent cacao, which was situated due east of the trap.

The fifth trap was set up on the old Bauxite workings at the summit of Mt. Ejuanema, Mpraeso, Kwahu, approximately 120 miles north of Accra (2100 feet above sea level). The nearest cacao farm was a mile away to the east, and the prevailing wind was north-east or south-west, according to the season.

The Tafo traps were examined for the first time on 29th August, the Oyoko trap on 28th August, the Aburi trap on 30th August, and the Mpraeso trap on 6th September, 1947. Owing to the civil disturbances that broke out in the Gold Coast at the end of February, 1948, it was not possible to change the Mpraeso trap on 6th March, and so the cylinder was left in position until 20th March, by which time it had been in the field for a month. Apart from this exception, every trap was examined once every two weeks.

METEOROLOGICAL DATA.

Rainfall figures for the experimental period are only available for Tafo, Aburi and Mpraeso. It is advisable to point out that the Tafo rain-gauge was situated three-quarters of a mile from the traps, the Mpraeso gauge just over half a mile away, and the Aburi gauge only 50 yards away. There were

no major topographical changes between trap and rain gauge sites, and so the figures in Table I may be taken as giving a fair estimate of the actual precipitation at each trap site.

TABLE I.—*Rainfall, Inches, as Total of each Two-weekly Period corresponding to the Trapping Periods for Each Station.*

Trap period.	Tafo.	Aburi.	Mpraeso.
1	3.72	1.04	3.45
2	4.79	3.30	8.35
3	3.69	5.96	5.73
4	5.32	1.16	5.93
5	2.58	2.59	2.09
6	1.60	2.19	0.88
7	1.65	2.60	2.67
8	1.44	0.90	2.20
9	0.31	1.43	0.20
10	0.02	1.32	—
11	—	—	—
12	0.03	—	—
13	0.26	1.10	1.18
14	4.55	0.01	2.98
15	5.18	6.33	0.07
16	1.56	0.87	1.93
17	2.82	4.41	1.43
18	0.75	2.30	2.54
19	4.52	1.88	9.09
20	4.97	2.02	2.44
21	3.92	3.17	10.78
22	10.91	3.10	3.37
23	4.08	0.23	4.20
24	2.14	0.70	1.87

RESULTS.

Since Pseudococcid "crawlers" are small and hard to see with the naked eye, every insect was removed from each trap with a needle and hand lens, and anything of the same size as a coccid crawler was mounted to confirm or negate identity. Little extra labour was involved in noting the total numbers of alate and apterous insects on the traps, and this additional information is tabulated below in the hope that it will interest others who may work with wind traps in tropical countries.

There is a noticeable degree of variation in the individual trap totals. It is not surprising, however, that the three cacao traps are all of the same order of magnitude, and the two hill-top traps are likewise almost identical. From an analysis of the full table, the only statistically significant difference lies in the Tafo "B" total compared with the Aburi and Mpraeso totals, and this is just significant at the 5 per cent. point. When the analysis was repeated using a log ($n+1$) transformation, however, it was apparent that both Tafo

TABLE II.—*Total Insects Caught in 24 Trap Examinations, August, 1947, to August, 1948.*

Trap period.	Tafo "A."	Tafo "B."	Oyoko.	Aburi.	Mpraeso.
1	1,774	1,318	1,099	2,342	936
2	1,731	1,506	1,304	3,041	990
3	1,416	1,385	1,692	2,661	1,418
4	1,353	1,400	1,204	2,724	3,433
5	1,393	1,050	1,206	2,605	2,370
6	986	825	1,036	2,293	10,052
7	898	651	1,305	3,509	11,561
8	891	704	1,092	2,627	1,586
9	807	663	871	1,702	1,658
10	1,093	853	667	1,862	1,377
11	1,054	868	928	1,300	720
12	1,782	1,062	1,547	1,389	2,096
13	2,179	977	1,190	1,655	2,280
14	1,860	1,743	1,617	2,097	} 3,340
15	1,427	1,307	1,756	1,969	
16	1,765	1,295	1,961	2,139	1,922
17	2,137	1,453	1,745	3,618	1,757
18	2,459	2,183	2,698	3,267	2,583
19	2,736	1,966	3,271	3,224	1,418
20	2,685	2,422	2,412	2,454	1,217
21	2,539	2,316	2,501	2,607	988
22	2,541	2,398	2,412	1,727	939
23	3,600	3,194	2,370	1,662	708
24	2,964	2,304	1,765	1,686	751
Totals	44,070	35,843	39,649	56,160	56,100

"B" and Oyoko were (at $p = 0.05$) significantly lower than Aburi, but not significantly lower than Mpraeso. From an examination of Table II it is clear that the Mpraeso figures (mean, 2337.5; range 10,841) exhibit a far greater range of variation than Aburi (mean, 2338.0; range, 2318), and that the Mpraeso trap site did not have such an abundant insect fauna as might be expected from an examination of the uncorrected figures. Periods 6 and 7 for the Mpraeso trap show a very considerable rise in total numbers of insects caught. Trap period 6 was cleared on 15th November, and trap period 7 on 29th November, and the increase in numbers is due to 8263 adult diptera being taken during trap period 6, and 9258 taken during trap period 7. Over the other trap periods an average of 311 diptera only were removed from each fortnightly collection at Mpraeso.

There are no significant correlations between trap totals and rainfall, even when using a log transformation. Two-way contingency tests do, however, give significant results when the numbers of insects caught over those periods when rainfall was above the mean are compared with the numbers caught when rainfall was below the mean for each trap site. These results are given in Tables III, V and VIII below.

TABLE III.—*Total Insects Caught in Relation to Rainfall.*

	Tafo "A."	Tafo "B."	Aburi.	Mpraeso.
Mean rainfall (in.)	2.96	2.96	2.02	3.06
Trap periods in which rainfall was above the mean	11	11	10	8
Trap periods in which rainfall was below the mean	13	13	14	16
Total insects taken when rainfall was above the mean	23,662	20,955	27,297	10,830
Total insects taken when rainfall was below the mean	20,408	14,888	28,863	45,270
Chi-square	0.59	1.57	0.46	3.04

On none of the traps was there a significant increase in total insects during the drier weather. It is clear, then, that rainfall has but little effect on the total numbers of insects passing through a given column of air over a two-weeks' period, at least so far as the Eastern Province of the Gold Coast is concerned.

TABLE IV.—*Total Apterous Insects Caught over the Experimental Period.*

Trap period.	Tafo "A."	Tafo "B."	Oyoko.	Aburi.	Mpraeso.
1	59	40	20	104	25
2	111	34	47	37	—
3	88	80	19	42	7
4	71	167	35	64	45
5	204	259	90	26	42
6	85	138	43	74	107
7	147	56	103	60	155
8	74	55	37	104	114
9	58	67	46	77	147
10	165	119	28	104	99
11	190	237	62	97	68
12	28	31	41	55	80
13	443	51	34	29	42
14	55	22	44	38	} 106
15	18	7	10	23	
16	33	76	11	21	44
17	27	30	8	26	55
18	46	63	36	22	27
19	43	14	225	28	38
20	18	26	27	34	28
21	20	16	55	37	17
22	11	17	21	20	13
23	14	18	27	25	19
24	76	43	15	30	8
Totals	2084	1666	1084	1177	1286

Table IV gives the figures for the apterous insects taken on the five traps. It should be noted that "apterous insects" is used to include spiders, mites, and other animals not members of the order Insecta. The degree of variation between trap totals is more pronounced than with total insects, though the two hill-top traps still show a good degree of agreement.

An analysis of variance carried out on these data shows that there were significantly fewer apterae taken at Oyoko as compared with Tafo "A" ($p = 0.01$), and at Aburi as compared with Tafo "A" ($p = 0.05$). Using the log $(n + 1)$ transformation, however, it is apparent that Mpraeso and Oyoko, but not Aburi, are both significantly ($p = 0.05$) lower than Tafo "A." This result again shows up the variability of the Mpraeso figures. Once more the Mpraeso range (155) was much greater than Aburi (84), and thus it is safe to say that, on the average, a smaller number of insects were passing through the Mpraeso trap site than through the Aburi site. Again, there are no direct correlations between trap figures and rainfall. Two-way tables, however, show that significant differences do exist between the numbers of apterae caught during periods of high and low rainfall.

TABLE V.—Total Apteræ Caught in Relation to Rainfall. (N.B.—Rainfall and trap periods as in Table III above.)

	Tafo "A."	Tafo "B."	Aburi.	Mpraeso.
Total apterae taken when rainfall above the mean . . .	508	441	367	164
Total apterae taken when rainfall below the mean . . .	1576	1225	810	1122
Chi-square . . .	5.88* ¹	4.58* ²	12.01*	8.75*

* = Significant at $p = 0.01$.

*¹ = Significant at $p = 0.02$.

*² = Significant at $p = 0.05$.

In every instance there were significantly more apterous insects taken during the drier weather than during the periods of heavy rainfall.

Table VI gives the total numbers of coccids taken on the five traps. Only three coccid genera were taken over the experimental period, *Pseudococcus*, *Stictococcus* and *Lecanium*, the latter *in sens. lat.* It is not possible to determine the specific identity of many of the first larval instars of African coccids, and no attempt has been made to do so here. Suffice it to say that all the common species of the local pseudococcids are known to transmit some or all of the viruses causing swollen-shoot disease, and further identification of the mealybug crawlers taken on the traps is unnecessary as far as virus is concerned.

The most striking points from these figures are first, that the three cacao traps have very many more coccids on them than the two hill-top, non-cacao traps. Secondly, there is a marked difference between the numbers of coccids caught on the Tafo "A" trap on a 2-foot pole, and the Tafo "B" trap on a 10-foot pole. The numbers of the three genera of coccids encountered are given in Table VII, and it will be noted that the higher numbers for the cacao traps are largely due to pseudococcid crawlers.

TABLE VI.—*Total Coccoidea Caught over the Experimental Period.*

Trap period.	Tafo "A."	Tafo "B."	Oyoko.	Aburi.	Mpraeso.
1	—	3	—	—	—
2	1	6	3	—	—
3	—	6	—	—	—
4	—	—	—	—	—
5	—	—	1	—	1
6	—	1	—	—	—
7	63	—	4	8	12
8	9	11	—	7	6
9	16	—	—	8	—
10	95	65	—	1	5
11	152	185	—	—	—
12	2	5	11	—	1
13	418	13	1	—	—
14	25	—	5	1	—
15	5	—	—	—	—
16	8	63	—	1	—
17	—	2	—	4	—
18	27	45	—	—	—
19	28	5	196	4	—
20	1	—	—	—	—
21	2	—	23	4	—
22	—	—	—	—	—
23	—	—	—	—	2
24	31	21	—	1	—
Totals	883	431	244	39	27

TABLE VII.—*Numbers of Individual Coccids of the Three Genera Encountered.*

Coccid genus.	Tafo "A."	Tafo "B."	Oyoko.	Aburi.	Mpraeso.
<i>Pseudococcus</i>	875	427	234	36	19
<i>Stictococcus</i>	3	1	4	2	2
<i>Lecanium</i>	5	3	3	1	6
Totals	883	431	241	39	27

From Table VII it is clear that the non-pseudococcid forms can be ignored as far as the cacao farm traps are concerned. It is of some interest, however, that the Mpraeso trap, the farthest away from a cacao farm, and standing in a clearing in secondary bush which did not contain many of the preferred food-plants of the known vector species, has the lowest numbers, and the lowest proportion (73·7 per cent. of the total), of vector to other species. Reverting to the major difference between the two Tafo traps, it is surprising that the trap with the largest number of mealybug crawlers on it should be the one on the 2-foot pole. The only tentative explanation advanced for this is that during trap period 13, at the end of February, 1948, eight or ten complete

ovisacs were carried on to this trap by ground-level air currents. This assertion is supported in so far as the coccids concerned (as with Tafo "A" 14 and "B" 14) were grouped in relatively small areas on the trap and not randomly distributed over the whole surface. Unfortunately, the "Ostico" used on the traps contained a wax solvent, and this, and the treatment to which the coccids were submitted for the removal of the "Ostico" in the mounting process, prevented certain identification of mature eggs as distinct from first stage larvae.

Owing to the number of blank periods in Table VI, no analysis of variance has been carried out on these data. Instead, a correlation between Tafo "A" and "B" has been made, and this shows that $r = +0.32$, which is not significant, indicating that the differences between the two traps are probably genuine, and may thus be due to their respective elevations. Table VIII shows the results of the two-way analysis carried out on the coccid-only figures.

TABLE VIII.—*Total Coccids Caught in Relation to Rainfall. (N.B.—Rainfall and trap periods as in Tables III and V.)*

	Tafo "A."	Tafo "B."	Aburi.	Mpraeso.
Total Coccoidea taken when rainfall above the mean .	62	20	16	2
Total Coccoidea taken when rainfall below the mean .	821	411	23	25
Chi-square	47.55*	60.74*	0.002	5.41* ¹

* = Significant at $p = 0.01$.

*¹ = Significant at $p = 0.02$.

With the exception of Aburi there are highly significant increases in the numbers of coccids carried about in air currents during the drier weather.

Aburi had the lowest rainfall of any of the trap stations, and the rain was more evenly distributed than at the other sites. From Table I it is clear that on only three of the trap periods did the Aburi rainfall rise above 3.3 inches, whereas at Tafo there were eleven, and at Mpraeso eight such periods. This may account for the fact that small numbers of coccids were taken at Aburi throughout the experimental period rather than most being taken in the short dry periods.

CONCLUSIONS.

The work outlined in the preceding pages answers the questions that arose from known facts about the spread of swollen-shoot virus of cacao. It is now clear that the major proportion of any virus spread which might be attributable to wind-carried mealybug crawlers occurs during dry periods. It is also likely that whole ovisacs are carried about in wind currents, and if this is eventually proved it will be of interest in so far as eggs do not act as virus vectors.

In relation to the total of 231,822 insects removed from the five traps over the experimental period, the numbers of apterous insects (7297) and coccids (1624) taken are negligible. Even this negligible proportion assumes some importance in the dispersal of such a dangerous disease as swollen-shoot,

but it is difficult to see how any airborne movement of coccids can be prevented except by the large-scale use of sprays and dusts in the dry season.

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BOOK NOTICE.

Ants. By JULIAN HUXLEY. 8vo. London (Dennis Dobson, Ltd.), 1950. Pp. 143, 8 half-tone plates. Price 6s.

A very condensed popular account of ant communities, intended to expose the fallacy of the parallels that are sometimes drawn between the social insects and human communities.

Life-histories, structure, caste differences, food supply, warfare, slavery, parasitism, and "guests" are reviewed. Termites are also included in this popular use of the term "ants." The emphasis of the book is sociological rather than entomological, but there is a short bibliography of six works in which first-hand information is available.

ON THE HEAD CAPSULE AND MOUTH PARTS OF *FORFICULA AURICULARIA* LINN. (DERMAPTERA).

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1. INTRODUCTION.

IN the course of an investigation of the growth of the Malpighian tubules of *Forficula* (Henson, 1946, *Proc. R. ent. Soc. Lond.* (A), **21**: 29-39), it was realized that, as a species, it was very favourable material for a study of the growth and development of external form. It was also apparent that such a study could not be undertaken on the basis of existing knowledge of Dermapteran morphology. Mr. W. D. Hincks, a well-known authority on Dermaptera, consulted at this stage, expressed interest and assured me that a greater understanding of morphology was an essential preliminary to an adequate treatment of Dermapteran systematics. This paper, therefore, together with others which it is hoped to publish in the near future, is intended to serve both of these purposes.

The transference of Mr. Hincks to Manchester prevented actual collaboration, as at first intended, but my warmest thanks are due to him for assistance in obtaining material and for directing my attention to points of systematic importance.

2. THE CRANIAL CAPSULE.

Compared with the generalized type, as interpreted by Snodgrass (1928, 1935), the head of *Forficula* is prognathous and somewhat distorted. It is much flattened, with broad facial aspect and narrow lateral aspect (*cf.* figs. 1A, 1D and 1B, 1C). The expansion of the upper part of the face is due to the inflation, as it were, of the genae. The prognathous condition, seen in comparing figs. 1B and 1C, is the result of the lengthening of the ventral margin of the cranium between the posterior mandibular condyle (a') and the maxillary condyle (a''), combined with a great increase in the angle between the posterior and ventral surfaces of the head (fig. 1C). It thus concerns only the mandibles, the maxillae and labium remaining attached in their normal posterior position. Since the region of the ventral margin concerned is named the hypostoma this particular type of cranial distortion may be known as *hypostomal elongation*.

Amongst the other general features of the head may be mentioned the extreme withdrawal of the ventral margin beneath the cranium, an effect presumably of genal expansion; the folding of the cranial edge around the base of the mandible to form a most efficient semicircular grip; and an apparent anterior and downward migration of the eyes and antennae which carries the latter almost to the upper border of the clypeus (*cf.* figs. 1A, 1D).

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The terms in which the form of the head has been described are intended to imply that its differences from the generalized type are the expression of differences in the relative rates of growth of the parts. Its chief features may be summarized as due to genal expansion, hypostomal elongation, the extension of the angle between the ventral and posterior surfaces, and the forward position of the eyes, antennae and mandibles.

The clypeus and labrum are large and separated by a well-defined clypeo-labral suture, the ends of which are marked by apodemal pits (fig. 1D, TMP) associated with chitinous bars on the under-surface of the labrum. These bars, the tormae (fig. 1E, TM), are evidently constant in form since, apart from occasional asymmetry, they are also similar to those figured by Cook (1944).

The clypeus is bounded posteriorly by a strong epistomal suture and is itself divisible into reasonably well defined ante-clypeus and post-clypeus (fig. 1D, ACL, PCL).

The true significance of head sutures is still imperfectly understood. Snodgrass (1935) speaks of them as lines left between areas of independent sclerotization. Ferris (1942) has made a most ingenious attempt to correlate sutures with the boundaries of the head segments, but Snodgrass (1947) seems to have invalidated this conception by showing that the coronal and frontal sutures are the ecdysial clefts of the head.

The term suture itself probably includes structures of more than one kind. The frontal suture, for instance, is a line of weak unpigmented cuticle which splits at ecdysis; the epistomal suture, on the other hand, is a line along which the cuticle sinks inwards to form a strong internal ridge. For this second type Snodgrass (1947) would prefer the term sulcus, but until the developmental relations of these various structures have been worked out there seems no reason why the term suture should not be used for any line.

The frontal suture varies greatly in position. In the lower insects it usually passes outwards across the face laterad of the antennal bases, in the holometabolous groups it normally passes mesad of the antennae. Crampton (1932), on the basis of a first instar larva of *Chorista* (Mecoptera), describes the first type as a post-frontal suture and the second as a frontal suture. This leads him to identify the suture in *Blatta* and *Gryllus* as frontal, and in Dermaptera, Phasmids and Mantids as post-frontal. Such an interpretation can hardly be established on such slender evidence, and is in any case completely refuted by Snodgrass (1947) when he shows that it is always the ecdysial cleft. The term post-frontal is unnecessary and might be discarded with advantage.

If it is conceded that the same suture can occupy apparently different positions on the head then it must be allowed that other head structures such as eyes and antennae can vary in position relative to the rest of the head capsule. This would be an effect of differences in the relative rate of growth of the various parts of the head, a conception which has been freely used in discussing the general form of the cranium in *Forficula*. Returning now to this type and using the above as a basis for interpretation the following sutures can be recognized.

The *post-occipital suture* (POS figs. 1B, C, E) is normal in form and encircles the *foramen magnum* except on the ventral side. Its corresponding internal

ridge is well marked laterally but is broadened and diminished in height on the dorsal side.

The *epistomal suture* (ES figs. 1A, D) marks the upper border of the clypeus. It extends between the two anterior pits of the tentorium (ATP) and possesses an extremely strong internal ridge.

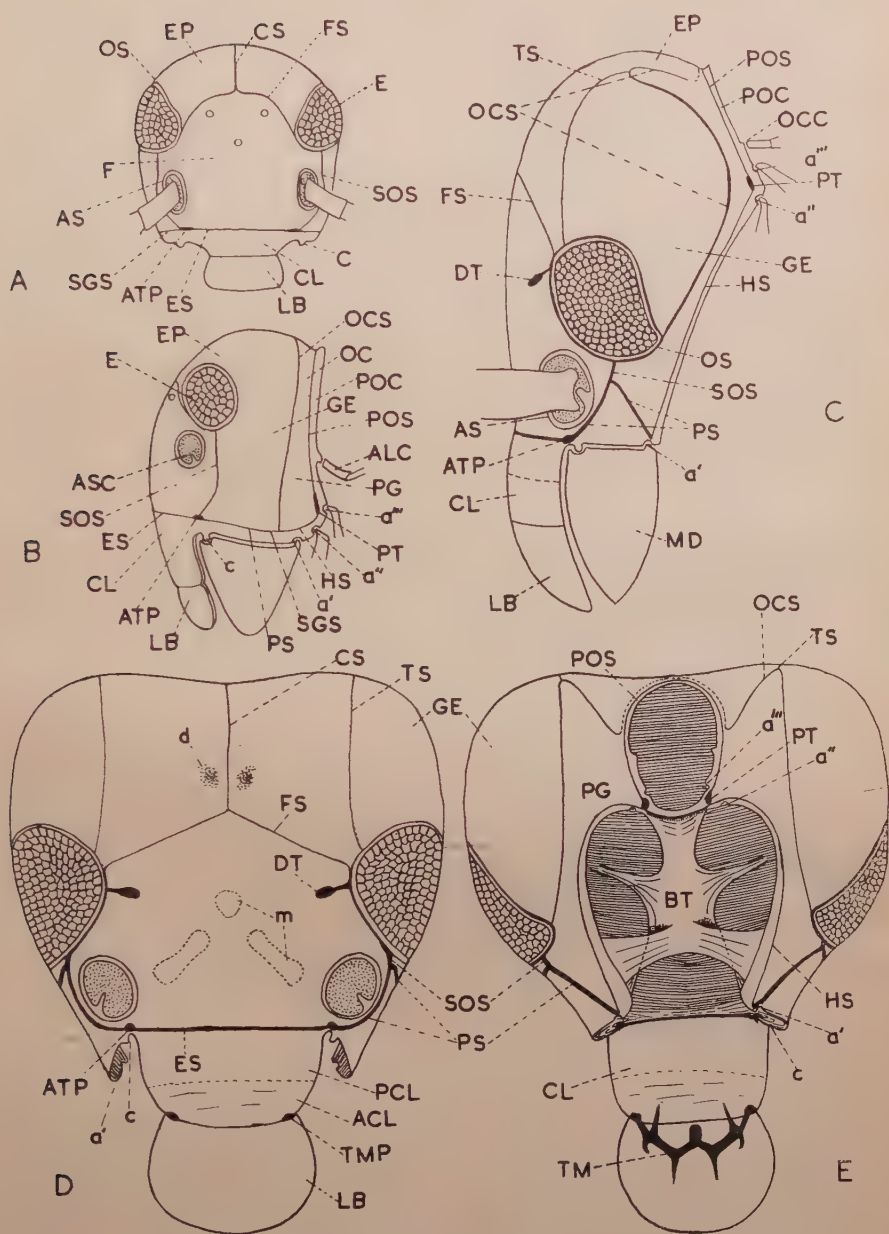
The *subgenal suture* (PS, HS, fig. 1B).—In a generalised insect this suture passes from the anterior tentorial pit (PT), close to the ventral margin of the head, backwards to the posterior tentorial pit. Its anterior half, above the base of the mandible, is the pleurostomal suture (PS) and its posterior half, from the junction of the occipital suture, is the hypostomal suture (HS). In *Forficula* (fig. 1C, E) the hypostomal suture is elongated because of the lengthening of this part of the head, whilst the pleurostomal is bent upwards into a Λ -shape encircling the region of the mandibular insertion. The internal ridge corresponding to the pleurostomal suture is powerfully developed to form a supporting brace for the insertion of the mandible. The anterior arm of the Λ curves round the antennal base and at its apex is joined to the ocular ridge by a short *subocular suture* (SOS figs. 1C, B). The ridge underlying the hypostomal suture is much less strongly developed.

The *occipital suture* (OCS, figs. 1B, C, E).—In a generalised type this suture runs from the posterior end of the pleurostomal suture over the back of the head to the corresponding position on the other side (1B). The chitinous area between the occipital and post-occipital sutures is the occipital arch, its upper part being occiput (OC) and its lower post-gena (PG). In *Forficula* the occipital suture is moved far out of its normal course by the genal expansion and hypostomal elongation. It probably arches over the *foramen magnum*, as shown by the dotted line (1C) and then, becoming visible on the dorso-lateral margin of the foramen, it bends forwards before turning sharply* to sweep downwards and forwards to the outer margin of the eye. There is no corresponding internal ridge. If this interpretation is correct the course of this suture shows that hypostomal elongation largely concerns the post-gena, which has spread forwards to the lower margin of the eye.

The *temporal suture* (TS, fig. 1D) is a faint line on the anterior aspect of the head extending from the occipital suture to the inner margin of the eye. It has no internal ridge.

EXPLANATION OF FIGURE.

FIG. 1.—A, Head of generalised insect, frontal view; B, same, lateral view; (A and B modified from Snodgrass (1935)); C, head of *Forficula*, diagrammatic lateral view; D, same, frontal view; E, same, postero-ventral view. *a'*, Posterior mandibular articulation; *a''* maxillary articulation; *a'''*, labial articulation; ACL, anteclypeus; ALC, ant. lateral cervical sclerite; AS, antennal suture; ASC, antennal socket; ATP, ant. tentorial pit; BT, body of tentorium; C, ant. mandibular condyle; CL, clypeus; CS, coronal suture; D, facial markings; DT, dorsal tentorial pits; E, eye; EP, epicranium; ES, epistomal suture; F, frons; FS, frontal suture; GE, gena; HS, hypostomal suture; LB, labrum; m, muscle impressions; MD, mandible; OC, occiput; OCC, occipital condyle; OCS, occipital suture; OS, ocular suture; PCL, postclypeus; PG, post gena; POC, post-occiput; PS, pleurostomal suture; PT, posterior tentorial pit; SGS, subgenal suture (PS + HS); SOS, subocular suture; TM, tormae; TMP, tormal pits; TS, temporal suture.



The *subocular suture* (sos, fig. 1B, c).—A prominent suture extending, in the generalised type, from the anterior tentorial pit to the lower margin of the eye, passing laterad of the antennal base. In *Forficula* (fig. 1c) it would seem that the upward arching of the pleurostomal suture has caused its coalescence with the lower part of the subocular suture.

The *coronal* (CS) and *frontal sutures* (FS) (fig. 1A, d) undoubtedly correspond to the ecdysial clefts of Snodgrass. If, however, they represent nothing more than this, their presence in an adult, which does not undergo further ecdysis, would not be readily explicable. In *Forficula* in particular they pursue the same course and are quite as strongly marked as in the nymph—in both nymph and adult the frontal sutures pass outwards from the coronal suture to the inner margin of the eye just above the dorsal tentorial pit. The wide separation of the suture from the antenna may be interpreted as due to the forward position of these latter organs. In the adult the coronal suture has a deep internal ridge, the frontal sutures have no such ridge.

The frontal region carries impressed marks (*m*), which, according to Cook (1944), are the origins of labral muscles.

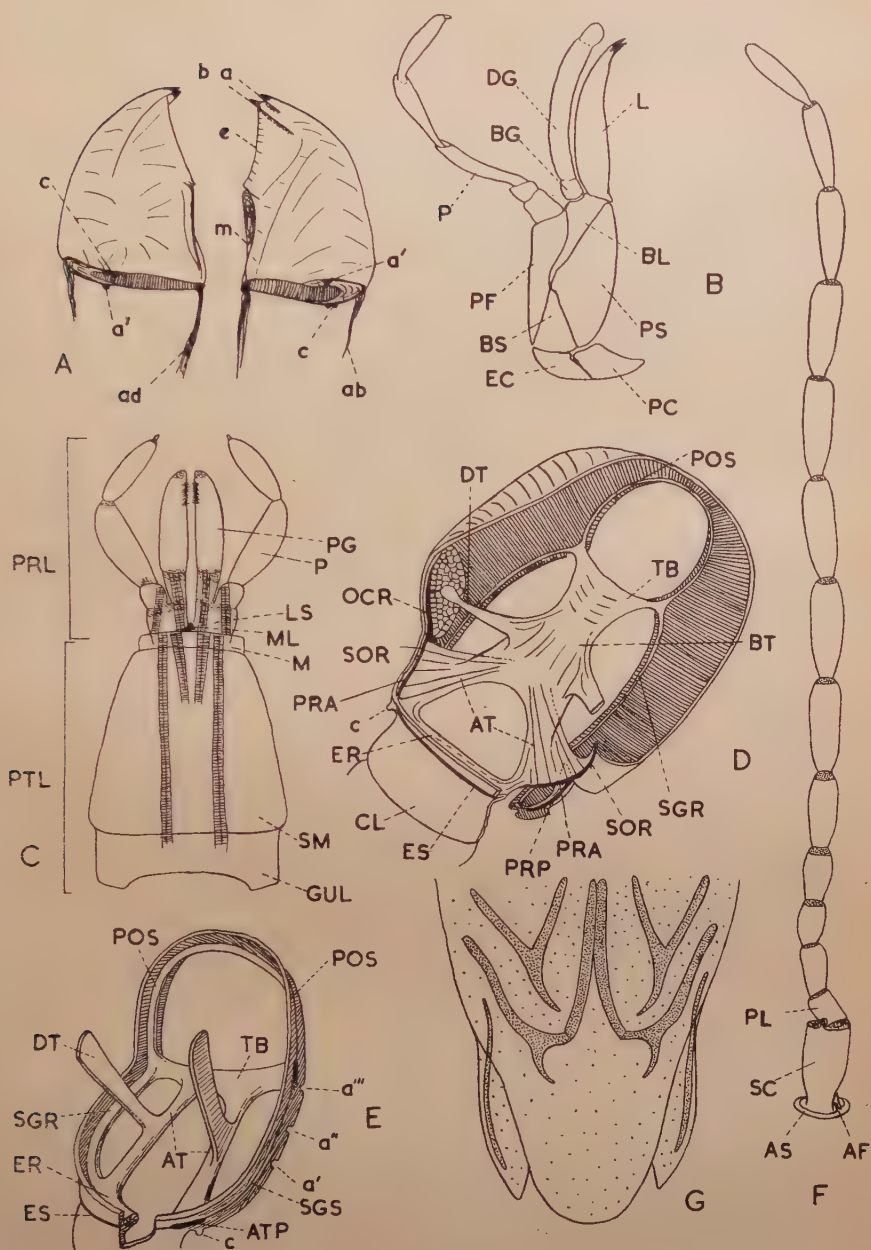
III. THE TENTORIUM.

The simplest form of insect tentorium is shown in fig. 2E (after Snodgrass, 1935). The apodemes from the posterior tentorial pits form the posterior bar (TB), those from the anterior pits form the anterior arms (AT). Arising from the anterior arms are a pair of upright dorsal arms (DT). In *Forficula* (fig. 2D) the anterior and posterior arms fuse to give a broad chitinous plate, the body of the tentorium (BT). The dorsal arms (DT) are well developed and fused to the frontal region just mesad of the eye. The anterior arms (AT) are broad and widely spread; each is attached to the cranium along the whole length of the anterior half of the pleurostomal ridge (PRA) and the subocular ridge (SOR). The internal ridge of the posterior half of the pleurostomal suture (PRP) forms a well developed bracket supporting the anterior arm from below. Following the pleurostomal ridge, as it does, the attachment of the anterior arm necessarily curves round the lower margin of the antennal base.

The relations of the anterior arm to the Λ -shaped suture above the mandible are clear evidence that this latter is correctly interpreted as a pleurostomal

EXPLANATION OF FIGURE.

FIG. 2.—A, Mandibles; B, maxilla; C, labium; D, the head capsule with much of the cranial wall removed to show the tentorium from above; E, generalized insect tentorium with its relations to the head capsule (after Snodgrass, 1935); F, antenna; G, hypopharynx. All figures except E are of *F. auricularia*. a, Tooth of mandible; ab, abductor tendon; ad, adductor tendon; AF, antennifer; AS, antennal sclerite; AT, ant. tentorial bar; b, tooth of mandible; BG, basigalea; BL, basilacinia (upper part of eustipes); BS, basistipes (lower part of eustipes); DG, distigalea; DT, dorsal tentorial arm; e, cutting edge of mandible; EC, eucardo; ER, epistomal ridge; GUL, gular; L, lacinia; LS, stipes of labium; m, molar area of mandible; M, mentum; ML, medilabium (reduced central part of prementum); OCR, ocular ridge; P, palp; PC, paracardo; PF, palpifer (outer part of eustipes); PG, paraglossa; PL, pedicel; POS, post-occipital suture or ridge; PRA, anterior half of pleurostomal ridge; PRL, prelabium; PRP, posterior half of pleurostomal ridge; PS, parastipes; PTL, post-labium; SC, scape; SGR, subgenal ridge; SGS, subgenal suture; SM, submentum; SOR, ridge of subocular suture; TB, posterior tentorial bar. Other letters as in Fig. 1.



suture. Moreover, this suture would itself appear to be a lateral extension of the anterior tentorial pit—a suggestion also offered by Ferris (1942) for the corresponding structures in *Gryllus*.

IV. THE ANTENNAE.

The antenna (fig. 2F) is a normal insect antenna with scape (sc), pedicel (PL) and flagellum. The edge of the socket has an antennal sclerite (AS), antennal suture and internal antennal ridge. The scape is attached to the socket by a pivot-like process of the antennal sclerite, the antennifer (AF). This is on the side towards the pleurostomal suture, i.e. the morphologically ventral side, so that the hypostomal elongation of the head and downward migration of the antenna have not involved any appreciable rotation of the antennal socket. The pedicel is articulated on the scape by a pivotal point almost diametrically opposite to the antennifer. The flagellum has 12 joints, the three basal ones relatively short, and the terminal nine rather longer and subequal.

V. THE MANDIBLES.

Each mandible has two articulations, a cup on its anterior margin fitting into a condyle on the head (*c*, fig. 2A) and a condyle on its posterior margin fitting into a cranial cup (*a'*). The orthopteroid mandible is normally uptilted anteriorly, but in *Forficula* the tilt is so exaggerated that the mandible is almost at right angles to the hypostomal margin.

The incisor region consists of two sharp teeth (*a*, *b*, fig. 2A) and a cutting edge (*e*). The molar region (*m*) is a blunt area admirably suited to its crushing functions. Yuasa (1920) gives an almost identical figure for *Anisolabis* and divides the teeth into distadentes (the apical pair) and proxadentes (the small tooth at the proximal end of the cutting edge). In view of this close agreement between the two genera it is somewhat surprising to find some specimens of *Forficula* with no cutting edge but two large teeth. The abductor and adductor muscles are attached as shown in the figure. There is no marked asymmetry of the mandibles of the two sides.

VI. THE MAXILLAE.

The maxilla (fig. 2B) is composed of the usual orthopteroid parts. The cardo, said to be fundamentally a single sclerite by Snodgrass (1928), is divided into eucardo and paracardo by Crampton (1921) (disticardo and basicardo, Crampton (1925), subcardo and alacardo, Yuasa (1920)). The stipes is also subdivided into regions named by Crampton (1921): palpifer (PF), basistipes (BS), stipes proper (PS) and basilacinia (BL). Crampton also asserts that this kind of subdivision occurs only in Dermaptera and some Coleoptera. Nevertheless, it is readily derived from the Blattid types where the stipe is divided by a longitudinal suture into a parastipes (PS) and a eustipes comprising the remainder of the sclerite. In *Forficula* the eustipes is subdivided by an oblique suture into a palpifer and a remainder which is separated into parts BL and BS merely by the contact of these two sutures in their middle portions. BL is thus not a basilacinia but a part of the eustipes.

The galea is divisible into basigalea and distigalea, but the lacinia is undivided and has two small but well developed apical teeth. The palp is five-jointed, with a small apical papilla on the terminal joint.

VII. THE LABIUM.

According to Snodgrass (1935) the insect labium is composed of two primary regions, prelabium (PRL) and post-labium (PTL) (fig. 2c). The prelabium is composed of a plate carrying the ligula and palps, the postlabium is a large plate subdivided into parts variously named mentum, submentum, gular, gulamentum, etc.

In *Forficula* the ligula has only one pair of lobes, usually interpreted as paraglossae on the grounds that the glossae tend to be reduced in the Orthoptera and that each lobe is two-segmented, like the maxillary galea (Imms, 1925). The labial palp is three-segmented and the terminal joint carries a small papilla as in the case of the maxillary palp. The median plate of the prelabium is, according to Crampton (1928), represented by a small medilabium (ML) (fig. 2c).

The postlabium is usually divisible into mentum and submentum, but in *Forficula* there are three plates (M, SM and GUL, in fig. 2c). Muscles and their attachments, some of which are shown in fig. 2c, prove conclusively that all three plates really are parts of the postlabium. The median muscles—the sternostipitals of Snodgrass (1935, p. 151)—equally prove that the narrow anterior plate is the mentum and that the long middle region is, at least in part, the submentum. Difficulty arises in the interpretation of the hindermost plate. Crampton, in his 1926 paper, when labelling his figures considered this posterior plate to be gular, but when writing the text he abandoned this interpretation. In his 1928 paper, however, he returns to his earlier views and considers that the postlabium consists of mentum and gulamentum, the latter dividing in Dermaptera into submentum and gular. Yuasa (1920) regards the "gular" as a neck sclerite. Snodgrass (1935) interprets the gular of Coleopterous larvae (e.g. *Silpha*) as a development of the ventral margin of the foramen magnum. It is evident that a comparative and developmental study of the Dermapteran "gular" is necessary before a fully acceptable interpretation can be expected.

VIII. THE HYPOPHARYNX.

The hypopharynx in *Forficula* is a large fleshy lobe with two small lateral wings, which undoubtedly represent the superlinguae. The base of the hypopharynx is furnished with a series of sclerites (fig. 2g), whose arrangement seems to agree to a large extent with the generalised form described by Snodgrass (1935).

SUMMARY.

1. The head-capsule and mouth parts of *Forficula auricularia* L., with their associated muscles, are described and figured.

2. The head of *Forficula* is derived from the generalised type (Snodgrass, 1928, 1935) by *hypostomal elongation*: the ventral margin of the cranium is

lengthened between the maxillary and posterior mandibular condyles. The eyes and antennae have migrated forwards and downwards.

3. The significance of *head-sutures* is discussed. The term "suture" probably includes structures of more than one kind, but until the origins of all these are understood it is useful to have a comprehensive term.

4. The *postlabium* is divided into three plates, of which the two anterior ones appear to be the mentum and submentum. The significance of the third plate is uncertain. It has been interpreted by some authors as a neck sclerite, but muscle-attachments indicate that it is a true part of the postlabium.

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THE LARVAE OF *MYSTACIDES AZUREA* L., *CYRNUM FLAVIDUS*
 McLACHLAN AND *OXYETHIRA SIMPLEX* RIS (TRICHOPTERA).

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IN recent years considerable attention has been given to the larvae of British Trichoptera. For a long time this group was, to a large extent, neglected, but many larvae can now be identified as a result of the work of Hickin (1942-48), who has given uniform descriptions of almost thirty species. His descriptions provide a standard for the following work in which three more larvae are described and discussed.

Even though it is now possible to identify many species, there is still some confusion and difference of opinion on the homologies of certain regions of the head and mouthparts that are of taxonomic importance. In particular the question of the gula or gular sclerite requires further investigation since some authors consider this sclerite to be part of the mentum. Das (1937) states that a true gular sclerite is totally absent in Trichopterous larvae, the so-called gular sclerite being the submentum. Snodgrass' statements (1935) support this view. Hickin (1946), whilst aware of these different opinions, retains the term "gula" in his papers. The clypeus, as the term is used by Hickin, refers to the region between the frontal suture and the base of the labrum, but there is some evidence that this region also includes the frons and should therefore be called the frontoclypeal region. Thus Das has shown, in *Anabolia*, that among the muscles arising on this sclerite are those of the labrum, which, according to Snodgrass, always originate on the frons. There is also difficulty at present in interpreting parts of the maxillae and labium. From a study of the musculature Das considers that the only existing endite on the maxilla is the lacinia. Nielsen (1948), however, in his work on HYDROPTILIDAE, refers to the endite as the galea. Hickin simply states that one or, in some cases, both endites are suppressed. Nielsen describes a palpifer in the maxilla, but according to Das this should be considered as the basal segment of the palp. Hickin is not wholly consistent on this point. In the following descriptions it has been decided to follow Das' interpretation. Das and Nielsen agree that there is a palpiger in the labium, and, on this interpretation, most species have only a one-segmented labial palp. Hickin, however, considers that the palp is generally two-segmented, since in a few cases the segments are clearly separated by a sclerite, suggesting that the basal segment is not a palpiger.

It is evident, therefore, that further work is required before these points can be settled. However, the present intention is to provide adequate descriptions and drawings for the identification of the larvae, whilst recognizing possible errors in terminology. Therefore, to preserve conformity with the descriptions already published by Hickin, it has been thought advisable to retain his terminology as far as possible. One minor change which has been

made is in the use of the term "parietals" for the lateral areas separated by the epicranial suture, and of the term "genae" for "the lateral parts of the parietals beneath or behind the eyes" (Snodgrass). The "vertex" is the region between and behind the eyes formed by the dorsal surfaces of the parietals.

MATERIAL AND METHODS.

All the larvae on which the following descriptions are based were collected from Auchentullich Bay, Loch Lomond, or from Cross Burn, which enters this bay (Nat. Grid. ref. 26/355868). The larvae were reared at Glasgow University Freshwater Station, Rossdhu, Loch Lomond, using small cages (12 in. \times 3 in. \times 3 in) of brass netting, each with a wooden base and a perspex lid. These were kept half immersed in a slow flowing part of Cross Burn. *Cyrmus flavidus* and many other species, however, failed to reach adult stage, though *Chaetopteryx* and other Limnophilids were very successful. *Oxyethira simplex*, because of its small size, was reared in petri dishes. Adult Trichoptera were identified from Mosely's key (1939).

DESCRIPTIONS.

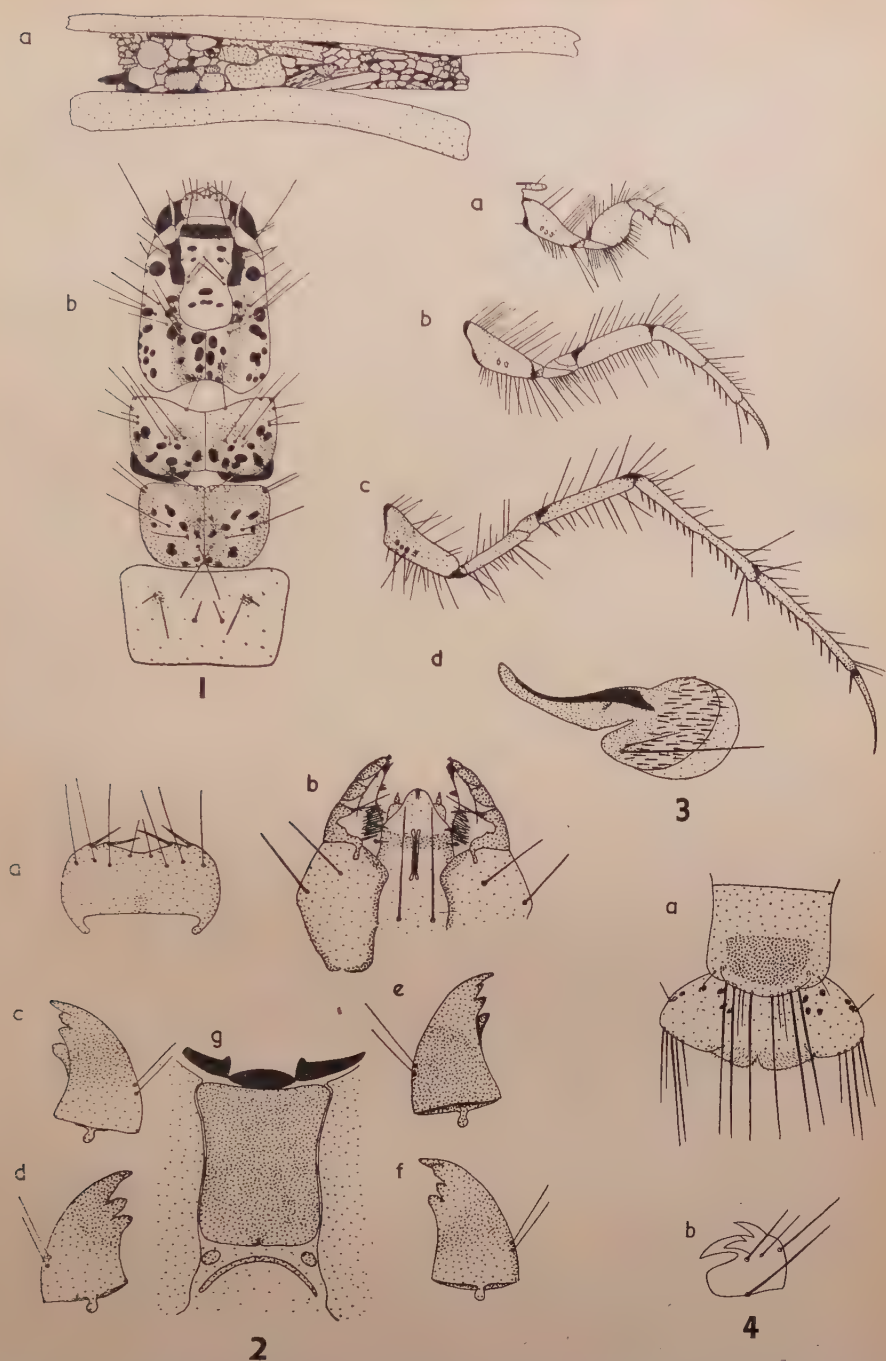
Mystacides azurea L. (LEPTOCERIDAE).

Larvae of this species were collected from Auchentullich Bay, at depths from 0.3–4.5 m. They were very abundant between 2 and 3 m. on a substratum of sand and *Isoetes*, and where there was a considerable amount of vegetable debris.

Larval case.—The case (fig. 1, *a*) is composed of vegetable fragments and a few small stones, often with one or two small twigs or stem portions running longitudinally along the case, extending beyond either or both ends. The length, excluding the projecting twigs, may reach 15 mm. and the width 2 mm.

Larva.—The larva is eruciform, with the pro- and mesonotum entirely sclerotized, but the metanotum is soft except for a pair of small sclerotized areas. The abdomen is white and has no gills. When fully grown the larva is about 12 mm. in length and 1 mm. in width.

Head.—The head (fig. 1, *b*) is long, with small ovoid and larger rectangular black markings on a light golden yellow background. The clypeus is twice as long as broad, and posteriorly it bears an oval black mark (a pair of spots fused) with a transverse row of three or four spots behind it. Anteriorly, there are two pairs of spots, the hinder pair being sometimes indistinct. The anterior margin is bounded by a wide black transverse band. On each side of the coronal suture there is a series of large rounded black spots, extending along the parietals to the frontal sutures. From the centre of each of the latter sutures to the anterior margin of the parietals, runs a wide black band. Each parietal has an irregular broad light brown band on the posterior two-thirds surrounding some of the black spots. On the genae are numbers of black spots extending to the ventral side of the head. The chaetotaxy is as shown in the figure. The antennae are two-segmented, the proximal segment being large and bulbous, the distal, long and narrow and terminating in a seta. They arise on the anterior borders of the parietals (fig. 1, *b*). The labrum (fig. 2, *a*) is sclerotized on its anterior lateral margins and has an anterior median concavity, at the base of which arises a pair of setae. Running in a single transverse row are three pairs of setae, and there are two pairs of spines on the anterior margin, which is notched at their insertions. The mandibles are asymmetrical. The right mandible (figs. 2, *c*, *d*) has three teeth on its



FIGS. 1-4.—*Mystacides azurea* L.—(1) *a*, Case; *b*, head and thorax. (2) *a*, Labrum; *b*, labium and maxillae; *c*, right mandible (dorsal view); *d*, right mandible (ventral view); *e*, left mandible (dorsal view); *f*, left mandible (ventral view); *g*, gular sclerite. (3) *a*, Right prothoracic leg; *b*, right mesothoracic leg; *c*, right metathoracic leg; *d*, right lateral sclerite of first abdominal segment. (4) *a*, Anal sclerite and appendages (dorsal view); *b*, anal claw.

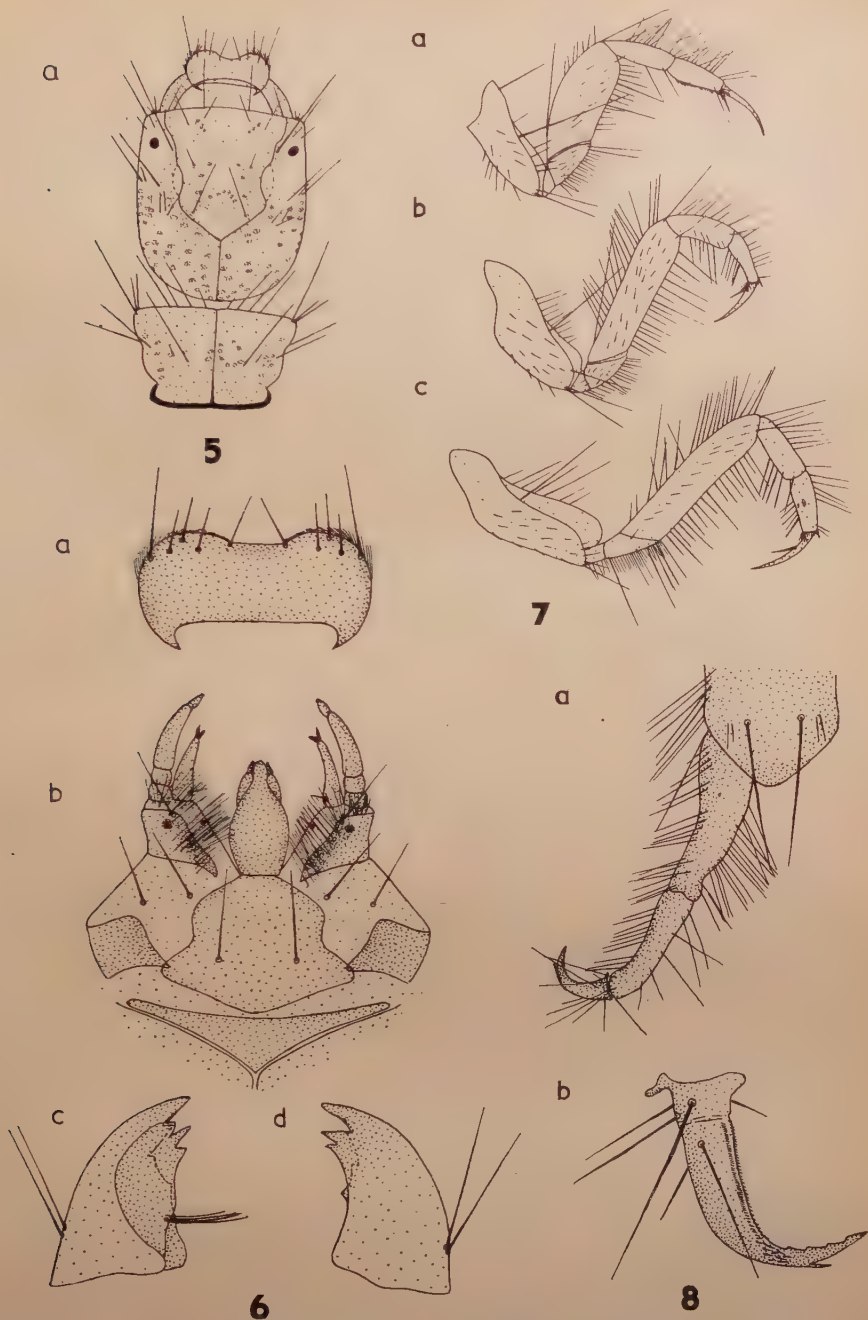
upper and two teeth on its lower sides. The left mandible (figs. 2, *e*, *f*) bears three teeth on both upper and lower sides. Each mandible has a pair of setae arising from the outer margin. The maxilla (fig. 2, *b*) bears a four-segmented palp, each segment being sclerotized on its outer surface, but the basal segment has an irregularly shaped sclerite whose inner proximal part is produced backwards. The distal segment has a few sense organs at its tip. The maxillary lobe bears a cluster of sense organs distally and one or two on its inner border. Proximally there are three inner spines and a series of fine hairs. The labial palps (fig. 2, *b*) bear a small papilla distally. In cleared, mounted specimens the silk press is clearly seen below the prementum. The gular sclerite (fig. 2, *g*) is rectangular and divides the genae, and has two small elliptical sclerites and a narrow, transverse, bow-shaped sclerite proximally.

Thorax (fig. 1, *b*).—The pronotum is sclerotized and is golden yellow in colour with dark markings. Except medially, the posterior border is black. A suture divides the pronotum longitudinally and on each side of it there is a brown horseshoe mark, the free ends directed forwards with one limb running near and diverging from the median suture, the other extending along the pleural border. Neither extends as far as the anterior margin. Superimposed on this horseshoe mark and within it, are a number of black spots. There is no prosternal horn. The mesonotum is sclerotized and is a little narrower than the pronotum. A suture divides it longitudinally into two sclerites, each of which is marked with light brown, only one small golden yellow area remaining in the centre, in and around which are about six black spots. On each side of the suture on the posterior margin are two additional spots. The metanotum is soft except for two small rounded lightly sclerotized patches, each situated midway between the centre and the lateral margins of the segment and bearing two setae. The prothoracic leg (fig. 3, *a*) is short, with a broad femur, and the distal end of the tibia is slightly dilated. The trochanter, femur and tibia each bears two spines on the under surface. In addition, the trochanter has a row of setae; the femur, setae and a series of fine hairs; and the tarsus, a series of small spinules on the lower margin. The mesothoracic leg (fig. 3, *b*) is longer with large numbers of setae on the coxa, trochanter and femur. In the latter segment the setae are regularly placed and are of uniform size, with the exception of four which are much longer than the rest. The under surface of both the tibia and the tarsus bears a series of four or five spines. The metathoracic leg (fig. 3, *c*) is the longest, with irregularly placed setae on the coxa, trochanter and femur, and a large series of equidistant spines on the tibia and tarsus, each of which has its distal half attenuated. The tarsal claw of each leg is relatively long and has a basal spine.

Abdomen.—The abdomen is white in colour and has no gills. The first segment has a dorsal and two lateral protuberances, each of the latter bearing a sclerite with two setae and a patch of small, forwardly directed spines (fig. 3, *d*). There is a lateral row of about twenty small, elevated, chestnut-coloured pustules on the 8th segment, in line with the lateral line of fine hairs on segments 3–7 inclusive. The anal sclerite (fig. 4, *a*), lying dorsally on the 9th segment, is half-moon shaped and brown in colour. On the posterior margin of this segment there is a series of setae. On the proximal segment of each anal appendage there are six or seven dark spots and five or six strong setae. The anal claw (fig. 4, *b*) is strongly curved and bears three mid-dorsal denticles, of which the middle one is smallest.

Cyrrhus flavidus McLachlan (POLYCENTROPIDAE).

Larvae of this species were collected from 0–4 m. in Auchentullich Bay, and also from Cross Burn. No adults were reared from these larvae, but they were identified from the descriptions and figures of Siltala (1903, 1905–06), Ulmer (1909) and Lestage (*in* Rousseau, 1923).



FIGS. 5-8.—*Cyrnus flavidus* McLachlan.—(5) *a*, Head and prothorax. (6) *a*, Labrum; *b*, labium, maxillae and gular sclerite; *c*, left mandible (dorsal view—dotted line represents ventral teeth); *d*, right mandible (dorsal view—dotted line represents ventral teeth). (7) *a*, Right prothoracic leg; *b*, right mesothoracic leg; *c*, right metathoracic leg. (8) *a*, Anal segment and appendage (dorsal view); *b*, anal claw (ventral view).

Larva.—The larva is campodeiform and has no case. The head and prothorax are sclerotized, the rest of the body is soft. The abdomen is slightly flattened dorso-ventrally. In a fully-grown larva the length is about 14 mm. and the width 2 mm. It is widest at the 3rd and 4th abdominal segments.

Head.—The head (fig. 5, *a*) is prognathous, with the genae running parallel for most of its length. It is golden yellow in colour, with light brown spots, which are not very distinct. The width of the clypeus at its anterior margin is almost as great as its length. Near the middle of this region there is a clear patch with a transverse row of about eight spots posteriorly, and two pairs antero-laterally. At the apex of the clypeus there is another clear area, triangular in shape and bounded on two sides by the converging frontal sutures. Near the anterior margin of the clypeus are two short oblique series of spots. On the parietals, at the level of the central clear patch of the clypeus, there is a fusiform light area, bounded on the inner side by the frontal suture. The posterior region of the parietals and genae have a large number of irregularly placed brownish spots. The chaetotaxy is as shown in the figure. The antennae arise on the anterior margin of the parietals and each is reduced to a small plate bearing three or four small setae and one or two sensory papillae. The labrum (fig. 6, *a*) has an anterior median emargination with a flat base, from each side of which arises a seta. Each antero-lateral region bears four setae and a brush of marginal hairs. The mandibles are acute and asymmetrical. The left mandible (fig. 6, *c*) has four teeth on the upper side and three on the lower, two of the latter being very small. The right mandible (fig. 6, *d*) has three teeth on both the upper and lower sides, and again two of the lower teeth are very small. Only the left mandible has an inner brush of three or four setae, but both have two setae arising from the outer margin. The maxilla (fig. 6, *b*) has a five-segmented palp, the 3rd segment being very long. The basal segment bears large numbers of fine hairs and a strong seta on the inner distal margin. The maxillary lobe bears two papillae at its tip, and one or two spines on its inner margin. The labium (fig. 6, *b*) has an acute ligula with the palps lying close to it, and a broad mentum bearing two setae. The gular sclerite (fig. 6, *b*) is narrow, transverse and triangular and does not divide the genae.

Thorax.—The pronotum (fig. 5, *a*) is golden yellow in colour, except along the posterior margin, which is dark brown. There is a transverse furrow posteriorly, extending to the pleural regions. Scattered over the surface are a number of light-brown spots. There is no prosternal horn. The meso- and metanotum are soft and do not bear any sclerites. The legs are all strongly built, lengthening progressively posteriorly. The prothoracic leg (fig. 7, *a*) has a regular series of setae on the under surfaces of the trochanter and femur. From the upper borders of the tibia and tarsus arise large numbers of setae, and on the lower border of the latter segment there is a series of small spinules. The mesothoracic (fig. 7, *b*) and metathoracic (fig. 7, *c*) legs resemble each other in many points, each having a series of fine setae on the lower margin of the trochanter and a large number of strong setae on the upper and lower surfaces of the femur. The tibia and tarsus of both have an upper and lower series of setae, and the most distal seta of the lower tarsal series is plumose. On each tarsus also there is a small spine on the upper margin at the distal end. The tarsal claw of all three legs has a ventral spine near its base, around which is a series of fine hairs and several small plumose setae.

Abdomen.—The abdomen is slightly flattened dorso-ventrally, with clearly defined segments. Each segment has a faint pattern dorsally and there is a fringe of long fine hairs laterally on segments 1–8. On the dorsal side of the 9th segment are five small eversible gills. The anal claw (figs. 8, *a*, *b*,) is long and strongly curved, with two fringes of spinules on the inner margin extending to the angle of the claw, where they meet a group of small spines. Distally the inner edge is barbed, forming four blunt teeth pointing towards the base. On the outer side, at the angle of the claw, there is a strong projecting spine. From the proximal region of the claw arise a number of long setae. The two supporting segments, which with the claw form the anal appendage, are densely fringed with long fine setae.

Oxyethira simplex Ris (HYDROPTILIDAE).

Larvae of *O. simplex* were collected from Auchentullich Bay at 3 m. on a substratum of sand and gravel with *Isoetes*. A number of pupae were found attached to stones, which were covered with algae, at the mouth of Cross Burn and round the shore of the bay.

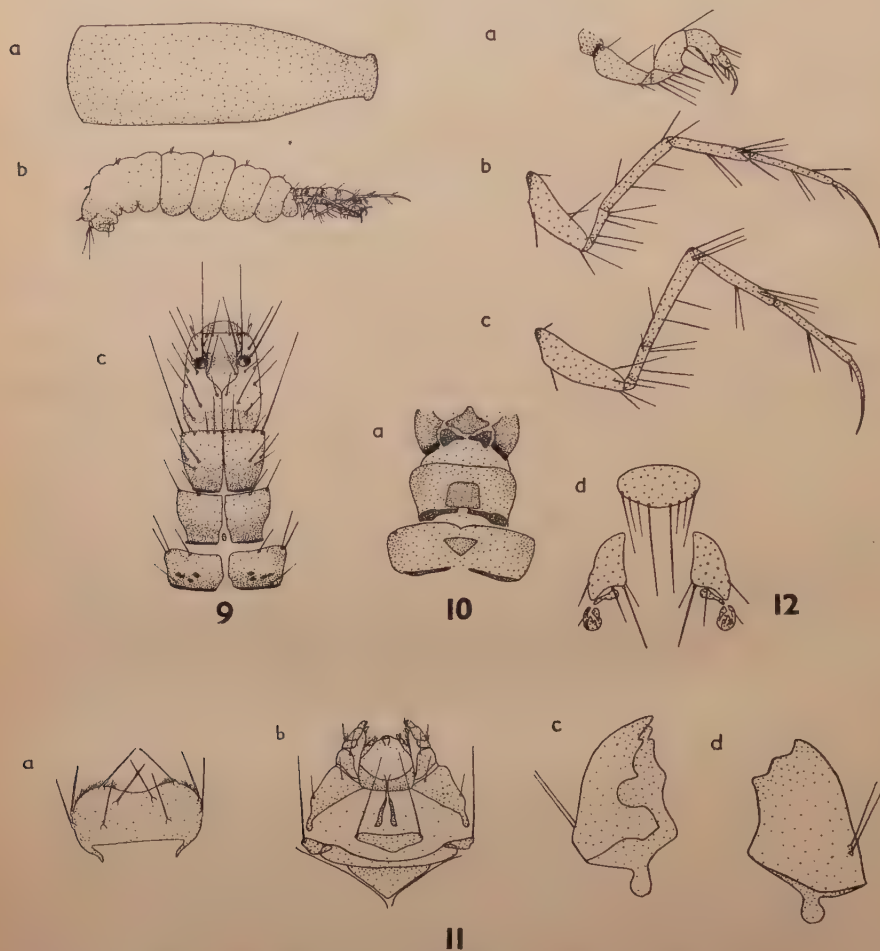
Larval case.—The case (fig. 9, *a*) is 3.5 mm. long and a little over 1 mm. at its broadest part. In lateral view it is flask-shaped, broad posteriorly and tapering anteriorly. The whole case, except the neck region, is strongly laterally compressed. It is entirely composed of silk secreted by the larva and is open at both ends.

Larva.—The larva (fig. 9, *b*) is campodeiform, with the head, pro-, meso- and metanotum sclerotized. The abdomen, white in colour, is relatively very large and is slightly curved downwards posteriorly. Like the case, it is flattened laterally, with the exception of the head and thorax. The length of the larva is about 3 mm. and viewed laterally, it is broadest at abdominal segments four and five, where it is a little less than 1 mm.

Head.—The head (fig. 9, *c*) is roughly elliptical in shape, and pale yellow in colour, with the posterior third brownish. There are also two brown patches on the clypeus between the eyes. The latter are very big, with the cellular elements visible through the lightly pigmented integument. The chaetotaxy is as shown in the figure. The antennae arise from the anterior margin of the parietals and consist of a bulbous basal segment and a long stout distal segment. Midway along the latter there is a conspicuous little knob, from which arises a very long seta, and distally a little clear cap. The labrum (fig. 11, *a*) is transverse, with a median anterior concavity. Each lateral margin bears three spine-like setae, the posterior two lying close together. There is also a brush of marginal hairs. Near the centre are two other pairs of spine-like setae, which, like those on the margin, are elevated on small tubercles. The mandibles are asymmetrical. The upper side of the left mandible (fig. 11, *c*) has three teeth, the posterior two small and blunt, the remaining one large and acute. Proximally there is a deep indentation. The lower side has three small rounded teeth. The right mandible (fig. 11, *d*) is obtuse with only three blunt teeth dorsally. Ventrally there is one blunt tooth. Each mandible has two setae arising from the outer surface. The maxilla (fig. 11, *b*) has a four-segmented palp, the distal segment bearing a large papilla on its inner surface. The maxillary lobe is obtuse, and lies close to the palp and bears large numbers of sense organs and hairs on its inner side. The labium is broad and blunt and the labial palps bear small papillae. The gular sclerite (fig. 11, *b*) is transverse and triangular and does not divide the genae.

Thorax.—The pro-, meso- and metanotum (fig. 9, *c*) are sclerotized and become progressively broader. The posterior half and lateral margins of each notum are light brown in colour, merging into the pale yellow of the anterior regions. The posterior margin of each segment is black and heavily sclerotized. The metanotum has a few dark spots in the posterior region. Each notum is divided by a longitudinal suture into two sclerites. On the pronotum these sclerites run together anteriorly, but separate posteriorly; on the meso- and metanotum the sclerites are clearly separate, and in the former there is a small elliptical sclerite lying between them. The thoracic segments also have a number of small sternal plates (fig. 10, *c*). The prosternum has a diamond-shaped sclerite supported by two others, which are triangular in shape. The mesosternal plate is quadrangular, almost square, and that of the metasternum is small and triangular, lying nearer the anterior margin of the segment. The meso- and metasternal plates also have two supporting sclerites. The prothoracic leg (fig. 12, *a*) is short, with a relatively broad femur and tibia, the latter with a large dilation, projecting distally, on its under surface. Two setae arise from the tip of the dilation. Along the lower border of the tibia, extending to the extremity of the dilation, there is a series of spinules. Another series is present on the tarsus. The femur

also is dilated on its lower proximal surface and two setae arise from this protuberance. The trochanter bears one small and three long setae on its lower surface. The meso- and metathoracic legs (figs. 12, *b*, *c*) resemble each other in many respects, though the latter leg is slightly longer (ratio of legs, 6 : 12 : 13). The tarsal claw of each leg bears a spine at its base.



FIGS. 9-12.—*Oxyethira simplex* Ris.—(9) *a*, Case; *b*, larva; *c*, head and thorax. (10) *a*, Thorax, sternal sclerites. (11) *a*, Labrum; *b*, labium, maxillae and gular sclerite; *c*, left mandible (dorsal view); *d*, right mandible (dorsal view). (12) *a*, Right prothoracic leg; *b*, right mesothoracic leg; *c*, right metathoracic leg; *d*, anal plate and claws.

Abdomen.—The abdomen (fig. 9, *b*) is very large and is flattened laterally. Each segment bears a few small setae dorsally and on the 9th segment there is a dorsal anal plate (fig. 12, *d*), elliptical in shape and bearing four pairs of setae on its posterior margin. There are no external gills nor is there a lateral line. The anal claws (fig. 12, *d*) are very small, each consisting of a median claw and a few smaller supporting ones.

DISCUSSION.

Mystacides azurea can be readily distinguished from the two other recorded British *Mystacides* by the absence of abdominal gills. One of these, *M. nigra* L., which has been described by Hickin (1943), can also be easily separated from *M. azurea* by the markings on the head and thorax. According to Lestage (in Rousseau, 1921) *M. nigra* differs from the remaining species, *M. longicornis* L., in the arrangement of the gills on the abdominal segments. In the former, gills are present on segments 2-4, in the latter, segments 2-7 or 2-8. Gill features are often unreliable, however, especially in LIMNOPHILIDAE.

The genus *Cyrnus* contains three British species, all of which are characterized by four small teeth on the inner distal margin of the anal claw. The identification of *C. flavidus* is based on the descriptions and drawings of Siltala, Ulmer and Lestage. According to Lestage the head and prothoracic markings are indistinct in *C. flavidus*, in contrast to those of *C. trimaculatus* Curtis and *C. insolutus* McLachlan. In *C. trimaculatus* there is a clear brown band following the epicranial suture, whilst in *C. insolutus* the head is mainly brown, or brownish only on the clypeus and its surroundings, without any pronounced bands. Lestage also states that *C. trimaculatus* and *C. insolutus* are smaller than *C. flavidus*, being only 10 or 11 mm. in length.

Oxyethira simplex belongs to a genus containing seven recorded British species, most of which are unknown in the larval stage. *O. costalis* Curtis has been recently studied by Nielsen (1948) and his work includes accounts of the case-building and feeding habits.

ACKNOWLEDGMENTS.

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SUMMARY.

The terminology used in descriptions of larvae of Trichoptera is briefly considered.

The method used for rearing larvae is described with reference to its efficiency.

Descriptions are given of the larvae of *Mystacides azurea* L., *Cyrnus flavidus* McLachlan, and *Oxyethira simplex* Ris, which are then discussed in relation to allied species.

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BOOK NOTICES.

The Natural History of Mosquitoes. By MARSTON BATES. 4to. New York (The Macmillan Company), 1949. Pp. viii + 379, 16 half-tone pls., 8 text illust. Price 25s.

A comprehensive survey of the whole field of mosquito biology, starting with the environment of the adult, survival and dispersal, sexual behaviour, and food habits, and leading on to a study of each of the immature stages, egg, larva and pupa.

There is a chapter on the classification of larval food habits, and an outline scheme for classifying breeding-places. Mosquitoes as vectors occupy two chapters, and classification and the species-problem another two.

Distribution, present and past, is summarized, and there are final chapters on techniques in the study of mosquitoes, and the strategy of mosquito research. The systematic list of mosquito species follows a classification based on Edwards' volume in *Genera Insectorum*.

The bibliography occupies forty-six pages, and the index eleven.

Principles of Insect Pathology. By EDWARD A. STEINHAUS. 4to. New York and London (McGraw Hill & Co.), 1949. Pp. ix + 757, 219 figs. Price 68s.

A review of the diseases and pathological conditions to which insects are liable, and the application of this knowledge in the control of insect pests.

The field covered includes mechanical, physical and chemical injury, diseases of nutrition and metabolism, bacterial, fungoid, virus, protozoan and nematode infections, and general topics such as symptoms and pathology, resistance and immunity.

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